SUPPLEMENTARY MATERIAL Accelerometry measured movement behaviors in middle aged and older adults: cross-sectional analysis of the ELSA-Brasil study

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1 Supplementary methods section: Protocol for accelerometry data
data collection, cleaning and initial analyses

Choice of device

We used the ActiGraph wGT3X-BT (ActiGraph, Pensacola - Florida, USA), registered in the Brazilian Agency of Telecommunications (ANATEL), under the homologation 06586-19-09607. The device is a compact (3.3 x 4.6 x 1.5 cm), lightweight (19 grams) triaxial piezoelectric accelerometer capable of recording accelerations between -8 and 8 g (1 g = 9.8 m/s²) and frequencies between 30 and 100 Hertz (repetitions/second). The device has been validated in adults and older adults.²,³

Device placement

Considering the higher accuracy of waist-placed, as opposed to wrist-placed, accelerometers in identifying physical activity time and intensity,⁴,⁵ and their higher correlation with energy expenditure,⁴,⁶ when weighed against the greater inconvenience for participants and reduced accuracy in identifying sleep outcomes of waist vs. wrist placement,⁷ we opted for waist placement.

Activation Parameters

We activated the devices using the Actilife software version 6.13.4 (ActiGraph, Pensacola - Florida, USA)⁸ the day before the participant visited the study center and verified calibration and battery charge. Activation parameters were: 1) Unfiltered raw acceleration record for the three axes 2) 30 Hertz sample frequency.

Recording length

Subjects used the accelerometer for seven days, starting at 8 pm on the day of the visit to the study center (day 1) and ending at 8 pm on the eighth day, as shown in Supplementary Figure S1.

Considering that continuous use of the device would likely generate higher
compliance and an accompanying sleep diary could minimize misclassification between sleep and sedentary behavior, we chose to collect data continuously over the seven-day period.

**Sleep diary**

As there is a lack of validated algorithms for sleep detection in waist-worn accelerometry, we requested participants to complete a sleep diary, recording daily information on the time they went to bed, time until they fell asleep, time they woke up, and time from waking until leaving the bed, over the period of accelerometer use.

**Number of devices needed**

Apart from the eight days of collection, we estimated another five days to make the accelerometers available for subsequent use - three days to return the device and two days to sanitize, charge, and reactivate. Therefore, we multiplied the expected weekly flux of 245 participants by a factor of 1.7, estimating the need for 420 devices.

**Handing the device to participants**

At the end of the clinical assessment visit (Day 1), research assistants provided instructions on device use. They explained how to adjust the waistband and place the device above the right anterior superior iliac spine, aligned to the top of the right knee. Participants were asked to remove the device when engaging in water-based activities (e.g., swimming). Finally, research assistants provided instructions on the completion of the sleep diary. To secure the device to the waist, some centers provided two disposable elastic bands to each participant and others used the manufacturer’s elastic band, sanitizing it after each use. Participants left the study center wearing the device.

Support and additional guidance were available to participants by phone during commercial hours. In addition, research assistants called the participants on the second day of the protocol to check if they had any questions and to reinforce proper use of the device.

**Return of the device by participants**

Research assistants called participants the day before the second in-person appointment (between 9 and 12 days after the first visit), reminding them of the accelerometer return. In this second appointment, research assistants collected the device, downloaded the .gt3x files, identified it with the participant's study registration number, and screened the sleep diary for missing information. According to the Choi algorithm, participants who did not reach 60% of the protocol (100.8 hours out of 168) were invited to repeat the collection.

We generated a report with the number of steps per day and estimates of moderate and vigorous physical classified by the Freedson algorithms using the Actilife software data processing tools. This information was returned to the participant as immediate feedback during the return clinic visit as well as sent by e-mail.

**Data storage**

For each participant, recording during the collection period generated a gt3x file size ranging from 40-50MB. We uploaded files through the data entry system to a Universidade Federal do Rio Grande do Sul server. This solution allowed data centralization and prompt access to the data for processing for future access by the researchers.
Data cleaning and processing

We initially identified accelerometer files smaller than 2 MB as containing insufficient data. We deemed participants presenting these files as non-adherent if there was no evidence of the device malfunctioning. In addition, we developed a routine to contact participants who did not return the accelerometers as planned.

We converted valid gt3x files to comma-separated values (.csv) format in the Actilife software. Then, we processed them using the GGIR package, available for the statistical software R, with the following steps:

1. Autocalibration against local gravity was performed to guarantee comparability between different units of accelerometers. Next, we excluded individuals for whom calibration was not possible or with a post-calibration measurement error of more than 0.2 g (1 g = 9.8 m/s²).

2. Non-wear time was identified by assessing the average for every 15 minutes window of raw acceleration for all three axes. If the standard deviation of acceleration for the 60 minutes centered in a given 15 minutes block was lower than 13 milli-g and the dispersion was less than 50mg, this 15-minute block was classified as non-wear time.

3. Raw acceleration data were collapsed into 5-second epochs based on previous research showing longer epochs smooth the gradient of acceleration intensity. In this sense, longer epochs may result in overestimation of LPA and underestimation of SB.

4. The acceleration summarized into the average ENMO (Euclidean norm minus one) of the three axes. The ENMO measure is obtained by calculating the acceleration magnitude vector of the three axes and subtracting 1 g, to account for the effect of the acceleration due to gravity \( \sqrt{x^2 + y^2 + z^2} - 1g \), rounding negative values to zero.

5. For periods with missing data, imputation was performed using the same subject's average ENMO for the same time of the day from all other sampling days that provided valid data.

Definition of valid daily observations

Stricter requirements of wear hours per day may enhance the reliability of movement behavior measures. Therefore, we defined the validity of a day as wearing the accelerometer for at least 16 hours. Loosening this requirement would produce a larger analytical sample but at the price of reducing the accuracy of movement behavior related outcomes.

2 Minimum number of days needed to measure overall activity

As the definition of what constitutes a minimum number of days observed is debatable and there is no consensus on the need to include weekends in the sampling period, we assessed the minimum number of days needed to produce a reliable estimate of overall activity in our sample and investigated differences in overall activity
across days of the week.

For this analysis we only included the 8473 participants who provided at least seven days with 16 hours of accelerometer wear. For this purpose, we used daily average ENMO (mg) with negative values rounded to zero to characterize overall activity as it represents average volume of activity over a given period. It is a proxy of energy expenditure measured by indirect calorimetry in laboratory settings and avoids the inherent errors imputed by misclassification when behavior classification algorithms are applied.\footnote{16}

To determine the minimum number of days acceptable for a reliable estimate of usual movement behaviors, we used the Spearman-Brown formula and estimated Intraclass-Correlation Coefficients (ICCs) for overall activity according to the number of measurement days.\footnote{17}

We used a two-way consistency model to calculate the ICC for seven days of accelerometer use.\footnote{18} We then used the adapted Spearman-Brown Prophecy Formula\footnote{13} and produced point estimates and 95\% confidence intervals for the ICCs for 2, 3, 4, 5, 6, and 7 days of measurement. Briefly, this Spearman-Brown formula was developed to study the impact of changing the number of questions on the reliability of a test, expressed by the ICCs. We calculated the number of days needed to reach an ICC of at least 80\%. This threshold implies that 80\% of the variability of mean values would be explained by the variation between individuals, as opposed to random error or within-individual error resulting from the number of recorded days. These analyses were run for each separate behavior.

**Data analysis**

We performed a graphical exploration of the overall activity with histograms and quantile-quantile plots to check for normality. Next, we described mean and median acceleration for each day of the week and explored differences between days of the week using the Kruskal-Wallis’s test. Finally, we ran Dunn’s post-hoc analysis to identify pairwise differences if the Kruskal-Wallis’s test showed overall differences. For our study, we have set the two-sided $\alpha$ at 0.05.

We then calculated the ICC for a single day of accelerometer use based on a two-way consistency model.\footnote{18} Using the adapted Spearman-Brown Prophecy Formula\footnote{15} we calculated the ICCs for log-transformed overall daily, Moderate and vigorous, and light activity, sedentary behavior and sleep with two to seven days of measurement and estimated the number of days needed to produce an ICC of $\geq 0.8$. We log-transformed the acceleration values because its distribution was right-skewed and did not fulfill the ICC symmetry assumption. Results can be found in **Supplementary Table S1**. Finally, we produced Bland-Altman plots for overall activity to visualize the agreement between 7 days of collection and a random selection of fewer days from the same participant.\footnote{19} **Supplementary Figure S2**.
3 Protocol references


4 Supplementary figures:

Supplementary Figure S1 – Accelerometry data collection protocol ELSA-Brasil (2017-2019)
<table>
<thead>
<tr>
<th>Days</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ICC (95%CI)</td>
<td>ICC (95%CI)</td>
<td>ICC (95%CI)</td>
<td>ICC (95%CI)</td>
<td>ICC (95%CI)</td>
<td>ICC (95%CI)</td>
<td>ICC (95%CI)</td>
</tr>
<tr>
<td>Overall activity</td>
<td>0.5 (0.51; 0.49)</td>
<td>0.67 (0.67; 0.66)</td>
<td>0.75 (0.76; 0.74)</td>
<td>0.8 (0.8; 0.79)</td>
<td>0.83 (0.84; 0.83)</td>
<td>0.86 (0.86; 0.85)</td>
<td>0.87 (0.88; 0.87)</td>
</tr>
</tbody>
</table>
Supplementary Figure S2 – Bland-Altman plots of overall acceleration according to a selected number of random days of measurement compared to a full seven days of measurement ELSA-Brasil Cohort Study (2017-2019) n = 8473

The black continuous line represents the average difference
Grey dashed lines are the intervals of agreement of 2 SD of the difference
### Supplementary Table S2 – Movement behaviors variation according to age for women, linear regression models ELSA-Brasil cohort n = (2017-2019)

<table>
<thead>
<tr>
<th></th>
<th>MVPA</th>
<th>LPA</th>
<th>SB</th>
<th>Sleep</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minutes/day</td>
<td>Minutes/day</td>
<td>Minutes/day</td>
<td>Minutes/day</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-49</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>50-59</td>
<td>-3.03 **</td>
<td>-0.59</td>
<td>-1.84</td>
<td>4.93</td>
</tr>
<tr>
<td></td>
<td>(-5.00; -1.06)</td>
<td>(-6.46; 5.28)</td>
<td>(-10.52; 6.84)</td>
<td>(-1.48; 11.33)</td>
</tr>
<tr>
<td>60-69</td>
<td>-11.07 ***</td>
<td>-8.43 **</td>
<td>7.85</td>
<td>10.76 **</td>
</tr>
<tr>
<td></td>
<td>(-13.10; -9.04)</td>
<td>(-14.47; -2.40)</td>
<td>(-1.06; 16.77)</td>
<td>(4.19; 17.34)</td>
</tr>
<tr>
<td>70-79</td>
<td>-24.63 ***</td>
<td>-31.60 ***</td>
<td>33.76 ***</td>
<td>21.15 ***</td>
</tr>
<tr>
<td></td>
<td>(-27.10; -22.16)</td>
<td>(-38.95; -24.24)</td>
<td>(22.89; 44.63)</td>
<td>(13.14; 29.17)</td>
</tr>
<tr>
<td>80+</td>
<td>-32.25 ***</td>
<td>-47.40 ***</td>
<td>52.76 ***</td>
<td>25.91 *</td>
</tr>
<tr>
<td></td>
<td>(-38.82; -25.68)</td>
<td>(-66.94; -27.86)</td>
<td>(23.88; 81.65)</td>
<td>(4.60; 47.22)</td>
</tr>
</tbody>
</table>

*p<0.05  **p<0.01  ***p<0.001

MVPA = moderate and vigorous physical activity; LPA = Light Physical activity; SB = sedentary behavior
Supplementary Table S3 – Movement behaviors variation according to age for men, linear regression models ELSA-Brasil cohort n = (2017-2019)

<table>
<thead>
<tr>
<th>Age</th>
<th>MVPA Minutes/day</th>
<th>LPA Minutes/day</th>
<th>SB Minutes/day</th>
<th>Sleep Minutes/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-49</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
<td>Reference</td>
</tr>
<tr>
<td>50-59</td>
<td>-1.51 (-3.94; 0.92)</td>
<td>3.02 (-3.68; 9.73)</td>
<td>-6.64 (-16.44; 3.17)</td>
<td>5.47 (-1.38; 12.33)</td>
</tr>
<tr>
<td>60-69</td>
<td>-12.89*** (-15.41; -10.37)</td>
<td>-14.50*** (-21.46; -7.53)</td>
<td>1.60 (-8.59; 11.78)</td>
<td>25.54*** (18.43; 32.66)</td>
</tr>
<tr>
<td>70-79</td>
<td>-26.42*** (-29.48; -23.36)</td>
<td>-30.83*** (-39.28; -22.37)</td>
<td>23.25*** (10.89; 35.61)</td>
<td>34.67*** (26.04; 43.31)</td>
</tr>
<tr>
<td>80+</td>
<td>-41.99*** (-47.94; -36.05)</td>
<td>-45.12*** (-61.56; -28.68)</td>
<td>49.46*** (25.42; 73.50)</td>
<td>38.28*** (21.49; 55.08)</td>
</tr>
</tbody>
</table>

MVPA = moderate and vigorous physical activity; LPA = Light Physical activity; SB = sedentary behavior